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MAIN ADDRESS

NUTRITIONAL VALUE OF SUNFLOWER SEED AND SUNFLOWER MEAL FOR LIVESTOCK ANIMAL.

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The availability of sunflower meal for animal feeding has been remarkably increasing during these last few years, thanks to the higher interest in the role of sunflower oil, which is rich in polyunsaturated fats, in human diet.
Besides sunflower meal as a protein source, also whole seeds can be used in animal nutrition thanks to their energy supply taken from lipids.
The quality of the meal, as a by-product of oil industry, depends on the methods which have been used to extract the oil, thus, on the residual quantity of fats, and on the crude fibre content.

Anti nutritional factors

The most important phenolic compounds which can be found in seeds and in sunflower's by products belong to the category of hydroxyl compounds of benzoic and cynnamic acids, and to the group of tannins.
The main compounds are the chlorogenic and caffeic acids. (Fig. 1)
Namely, the chlorogenic acid can be oxydized enzymatically or chemically in O - quinons, which polymerize very quickly and bind through a covalent bond to reactive groups of proteins.
O - quinons particularly bind with the Σ aminogroup of lysine, with the trypophane's indole group , and with the sulphydryl group of methionine, the consequences are the following:
- setting up of coloured compounds reducing the food's organoleptic properties, decrease of digestibility of proteins in monogastric animals, as well as a decreased availability of lysine, and methionine (1).
Many authors have pointed out that the detoxification of sunflower meal can be done by thermical treatment (surge tank at 120°C for 40 - 60 minutes), or by using solvents for the extraction. In this way, we can obtain a remarkable reduction in the chlorogenic acid content (55%), a reduction in the available lysine (about 20%), and a consequent enhancement of animal performances. However, other authors have observed that reduction in the P.E.R. and N.P.U. values took place after the treatment (3).
The biological effects of chlorogenic acid are not yet clear. Delic et al. found that when chlorogenic acid was fed to mice at a level of 2% of the total diet, food consumption declined by 33% and weight gain declined by 66%. Rats fed

a diet containing a 1% of chlorogenic acid did not show variations of P.E.R., biological value and digestibility of the diet. Furthermore there were no changes in the nitrogen balance or in hematological conditions.

Nutrient content of sunflower seeds

In the deep extraction with solvents, oil content can lower down to less than 3%, while in oil cakes, coming from pressure extraction, fats can reach 12%.
High oil or fibre contents are inversely related to high protein contents.
The complete dehulling of the seed before the extraction with solvents, make it possible to obtain meals with protein contents higher than 40%, and with fibre contents of about 12%.
If the seeds are not dehulled, protein contents will be 25-26%, and fibre about 30% (Table n.2). We have experienced a crushing technique which permits to enrich the protein contents of a portion, because of the cellular structure, and thanks to the consequent splitting up.
It should be noted that the increase in proteins of a portion implies a general considerable reduction of the ADF content. The fibrous parts of sunflowers contain a considerable amount of lignin. (Table n.3)
Non proteic nitrogen represent 6-10% of the total amount of nitrogen and is made up of nucleic acids and free aminoacids. The proteic portion includes about 20% (15-22%) of albumins, which are water-soluble, and 50% (46-53%) of globulines, which are soluble in saline solutions.
Thus, most proteins are represented by globulins (reserve proteins), with a molecular weight of about 300-350.000 and having an aminoacid composition lacking in lysine. Methionine contents of globulins is less high than that of albumins (1).
As a consequence, the value of proteins of sunflower seeds is definitively lower than that of other legumes (3.9 vs 6) or meals of animal origin (3.9 vs 6.9), although their percentage of lysine content is higher than in cereals.
On the contrary, sunflowers' proteins contain high quantities of other essential aminoacids, especially sulfurated (2.1% vs 1.3% soy-bean).
The lack of lysine reduces the nutritive value of this protein for the growth. The P.E.R. (protein efficiency ratio), of sunflower meal is 76% of that of soybean meal. Blending (1:1) sunflower with Legumes meal having an high-lysine content, result in an improvement of the nutritive value of the mix, with a P.E.R. higher than that of casein (2).
This effect is even more evident if sunflower protein are blended with proteins of animal source. (2).
However, row lysine content (on a crude protein basis) is rated between 54 and 66% compared to the soy-bean protein, while methionine is included in higher values, between 123 and 158%. (Tables n.4 and n.5).

Sunflower meal in pigs diets

The effects are due to the shortage of energy especially in the rations for adult pigs, and to the aminoacid composition of proteins.
The variability of the analytical composition of sunflower meal affects its utilization in the diet for monogastric animals.
The protein of sunflower is hardly lacks in lysine, and has a low intestinal digestibility because of the above mentioned phenolic compounds content.
Green, in 1989 showed no difference in that the overall digestibility of aminoacid from sunflower meal or soyabean meal (82%), while according to previous data (Sauer 1992), the ileum-caecum digestibility was 70.6% for lysine, 81.1% for methionine, 68.6% for threonine and 73.3% for phenylanine, thus a little lower than the data concerning soyabean meal.
The variability of these data could depend on the various treatments undergone during the production phase.
High fibre content (13-30%) and low energy influence the use of sunflower by-products, especially in the diets for weaning pigs, since, as a consequence, the ingestion and the efficiency are reduced. Furthermore, supplementation of lysine and methionine are necessary.
In some cases (Moser 1985) the performances of diets based on sunflower meal and corn were similar to the results of soy-bean diets on pigs of 10 kg. p.v., similarly to what was observed by Violjoen in 1988, with dehulled and oily sunflower seeds as a proteic source for weaning pigs (Table n. 8).
An increasing percentage of sunflower meal in the diet of pigs weighting from 25 to 45 Kg if well supplemented for aminoacid requirements, decrease feed efficiency, because of the lower energy supply and of the consequent unbalance between aminoacids and energy.
Some Authors (Seeley 1974, Dinusson 1982) pointed out that the supplementation with lysine can overcame the observed depression of feed efficiency when 40% of the soyabean meal is replaced by sunflower meal.
Walhstrom, using increasing supplementations of methionine, methionine plus lysine, triptophane and threonine, showed that triptophane and threonine are limiting aminoacids, as well as lysine, in diets rich in sunflower meal.
The supplementation with methionine of a diet integrated only with lysine, has improved the performances only of 3%.
Isoleucine and leucine had no effect.
Particularly marked are the effects on feed efficiency and quality of carcasses dehulled whole seed used as an energy and protein source for growing-finishing pigs.
According to many authors (Marchello 1983, Adams 1985, Hartman 1984), the characteristics of sunflower oil, rich in unsaturated fatty acids, causes pale, soft and exudate carcasse, and lower consistency of the fat because of the low level of stearic, palmitic and oleic acid and high content of lynoleic acid.
It is not possible to detect these effects if the diet not contain over 10-13% dehulled whole sunflower seed.

Sunflower meal is more suitable for the diet of pregnant sows, needing lower levels of proteins and lysine. Furthermore, the high fibre content has positive effects on dietetics characteristics of the ration.
Suckling sows need higher amounts of energy, compared to pregnant sows. In this case, whole sunflower is particularly suitable, as showed by Kepler in 1982. Diets containing 25% of dehulled whole sunflower seed increase remarkably the percentage of fat in milk (10,1 Vs 7,8%), but anyone particular effect has been found on performances of starter pigs (Table n. 10).

Sunflower meal in diets for broilers.

Also diets for broilers, containing sunflower meal as the only proteic source, show the specific lack of lysine as main limiting aminoacid (McGinnis 1948, Klain 1956) whose total addition does not permits, however, performances which can be compared to those resulting from diets based on soybean meal. The inclusions of sunflower meal in diets for hens causes a lack of threonine, as the second limiting aminoacid, after lysine.
The use of 2.0-2.5% of fish meal almost eliminates these lacks (Walter 1979), although the progressive introduction of sunflower meal in diets (13% max.) causes a proportional increment of the ingestion, due to the increased fibre level.

The nutritive value of sunflower meal for ruminants.

The nutritive value depends on the fibre content, although fibrous portions can be used in some ways for ruminants.
Proteins are easily soluble in water and have a high ruminal digestibility. Compared to soybean meal, the proteins of sunflower have a water solubility more than double (14.7 vs 6.2).
The rate of ruminal degradation (Kd) of the insoluble but degradable fraction, is more high compared to that of soybean meal (14.68 vs 8.25). Also the undegradable fraction, estimated after 14 days of rumen incubation, is particularly higher than that of soyabean meal, probably because of the high level of N bond to the fiber (N-ADF)(Table n. 11).
Considering a 6% rate of passage, the quantity of by-pass proteins is very low, if compared to other vegetable proteins.
The *in situ* method used to assess rumen degradability of protein, give an interesting but not completed information. It has also some limits, which have been summarised by Van Strade and Tamminga as follows:
1) Nylon bags' content does not undergone the crumbling due to the rumination.
2) The attachment of rumen bacteria to bags' content, bring about an overevaluation of the by-pass fraction, especially for feedstuffs with high rumen degradability.

3) The water soluble fraction, is not completely degradable in the rumen. It has been estimated that the amount of peptidic nitrogen leaving the rumen can change the true degradable value by 3-5%.

4) The rate of passage of feed particles is affected by their sizes and density. Recently, Tamminga has also showed that undegradable particles leave the rumen more rapidly than digestible particles.

Nevertheless, the bags method is the only technique providing comparative and reliable information on the kinetics of protein degradation into the rumen.

Table 13 and 14 summarize the differences in the formulations of rations for dairy cows (in diets based on corn silage and lucerne hay). due to the different composition and characteristics of proteins from soyabean and sunflower meal.

Compared to soybean meal, besides a shortage in methionine, there is a remarkable lack in lysine, that certainly can reduce milk production. The data of PDIE and PDIN values (Table n. 15) underline that, because of their high rumen degradability, the proteins of sunflower must be balanced with fast energy-supplying feedstuffs.

In sunflower and soy-bean's proteins, the difference between the ratio of PDIN to PDIE is remarkable. (Table n. 16).

However, such peculiarity reduces the use of this protein source in the diets for highly productive ruminants which have specific requirements of intestinal available aminoacids.

In ruminant, the use of high degradable proteins is limited by the ability of rumen bacteria to utilize ammonia deriving from the degradation of feed proteins, avoiding the absorption of ammonia and his accumulation in the blood as urea. The synthesis of urea from ammonia is an energy-expensive reaction.

In dairy-cows producing more than 15 litres of milk per day, the use of sunflower as the only protein source, determines a remarkable excess of rumen degradable protein, and a lack of intestinal available protein, with evident shortage of lysine, methionine and histidine for the synthesis of milk.

The lack in methionine is confirmed by Drackley (1989), by evaluating the uptake of serum aminoacids by the mammary gland. The use of soybean meal reduces this deficiency.(Table n. 17).

In beef cattle, the use of sunflower meal as the only protein source drive to a deficiency of the intestinal availability of lysine and methionine, particularly with young steers (250-400 Kg. p.v.), when ruminal bacterial synthesis is limited by low level of intake. At live weight more than 450 kg, the need to meet the requirements of degradable protein of rumen bacteria, makes very interesting the use of sunflower meal. The aminoacid composition of sunflower protein is the most limiting factor, driving, in this stage of growth, to a lack especially of lysine.

Steel (1989) shows that in beef steers fed *ad libitum* hay-silage, the supplementation of sunflower meal does not improve the performances, contrary to soybean proteins (+ 90 g per day), and to fish meal (+110 g per day).

Also for finishing beef steers, having reduced requirements for essential aminoacids, blending sunflower and soybean protein, is the best solution.

Following the new P.D.I. and U.D.P. methods, to asses the proteins for ruminants, it is necessary also to establish the digestibility of by-pass protein and of its aminoacids.
Thus, different kind of feeds with the same protein content, but with different ruminal by-pass, or different intestinal digestibility of the protein, will have a different supply of digestible aminoacids for the cow.
Our researches, carried out using dairy cows fitted with ruminal and duodenal fistula, have showed that sunflower meal has an high digestibility, expressed as "dr" (89,75%) not significantly differ from soybean meal (95.7%), corn gluten (95.7%), and fish meal (91.4%). Remarkable are instead, the differences in comparison with blood meal (26.4%9, and meat meal (67.5%). (Table n. 18).
With respect to the supply of digestible aminoacids per 100 g of proteins, sunflower meal is similar to soybean meal for methionine, but the supply of lysine is lower of 22%. (Table n. 19)
These results has been obtained using the mobile-bags technique, proposed by I.N.R.A. and utilized in several European Research Institutes.
In feeding trial Vincent (1990) have compaired soybean meal and sunflower meal as the main sources of protein, in concentrate supplementation given to dairy cattle producing 25 kg/d of milk, found no differences in milk production and composition.
Particularly interesting are the researches, concerning the use of whole sunflower seed or extruded in diet for early lactating cows.
Feeding early lactating dairy cows with whole sunflower seed as a fat supplement did not affect milk production in comparison with whole soybean (Drackley 1986) but decrease protein content (Drackley 1986, Mc Guffey 1982) from 2,91 to 2,74% in the first case and from 3,21 to 3,10% in the second. (Table n. 20)
The comparison between whole sunflower seed and whole soybean, or cotton seed, has highlighted the lower efficiency of sunflower in the production and in the quality of milk (Anderson 1983).
The most apparent consequence is due to the change in the acidic composition of milk fats, with a strong decrease of medium and long chain fatty acids, and an increase of unsaturated C:18, like oleic, linoleic and linoleic acids (Table n. 21).
This is certainly a positive effect for the nutritive properties of milk, but it can cause technical problems to certain kind of cheese and to butter, which is soft and tends to become rancid.

Conclusions

Sunflower seeds, meals and cakes play an important role in feeding livestock animal. Obviously, they can not replace soybean, but they can be included in diet for ruminants and pigs, balancing with suitable supplementation the deficiencies. When is used whole seeds, the fatty acid composition of sunflower oil can improve the dietetic properties of animal fats.

Table 1. Concentrations of phenolic compounds in sunflower meal. (Shamanthaka and Subramanian, 1985)

	% on D.M.
Chlorogenic acid	1.41
Caffeic acid	0.72
Quinic acid	0.33
Total phenolic compounds	2.46

Table 2. Proximal analysis of soyabean meal and different types of sunflower meal (as feed). (Thacker, Kirkwood, 1990)

	SOYABEAN MEAL	SUNFLOWER MEAL DEHULLED	SUNFLOWER MEAL PART. DEHULLED	SUNFLOWER MEAL NOT DEHULLED
Dry matter (%)	90.0	93.0	89.0	89.0
Digestible energy (kcal/kg)	3680	3047	2425	2337
Crude Protein (%)	48.5	45.5	32.0	26.0
Crude Fiber (%)	3.4	11.7	21.0	30.0
Ether extract (%)	0.9	1.6	0.5	0.5

Table 3. Analysis of different fractions from defatted sunflower meal obtained by means of breaking. (Piva et al., 1982)

	SUNFLOWER MEAL	FRACTIONS A	B	C
Ratio		1	13	1
Specific gravity	0.55	0.44	0.54	0.55
Moisture (%)	8.99	7.80	8.82	8.87
C.P. (% d.m.)	31.46	27.36	31.09	34.04
NDF (% d.m.)	35.64	19.23	41.91	36.45
ADF (% d.m.)	34.37	16.30	33.01	31.57
ADL (% d.m.)	9.32	5.21	9.69	8.72
Lysine (% C.P.)	3.74	3.67	3.76	3.66
Methionine (% C.P.)	1.96	1.76	1.54	1.68
Degradat. *in situ* of d.m. (%)	23.55	86.62	20.11	13.88

Table 4. Essential aminoacid content of soyabean meal and different types of sunflower meal. (% as feed)(Thacker, 1990)

	SOYABEAN MEAL	SUNFLOWER MEAL DEHULLED	SUNFLOWER MEAL PART. DEHULLED	SUNFLOWER MEAL WITH HULLS
PROTEIN	48.5	45.5	32	26
Arginine	3.67	3.62	2.90	2.10
Histidine	1.20	0.96	0.65	0.65
Isoleucine	2.13	1.97	1.45	1.05
Leucine	3.63	2.77	2.40	1.65
Lysine	3.12	1.68	1.35	0.90
Methionine	0.71	0.82	0.65	0.60
Phenylalanine	2.36	2.12	1.75	1.20
Threonine	1.90	1.63	1.30	1.25
Tryptophan	0.69	0.6	0.35	0.20
Valine	2.47	2.22	1.90	1.30

Table 5. Aminoacidic composition of two sunflower meals with different protein content.(% as feed)

AMINO ACID	34.76 % C.P. (d.m.)	39.89 % C.P. (d.m.)
Lysine	1.08	1.25
Histidine	0.87	0.91
Arginine	2.33	2.43
Threonine	1.11	1.18
Valine	1.49	1.63
Methionine	0.62	0.64
Isoleucine	1.26	1.29
Phenylalanine	1.37	1.49
Leucine	1.94	2.13
Tryptophan	0.34	0.39

Table 6. Swine performance on rations with sunflower meal (SFM) replacing soybean meal (SBM)(Dinusson et al., 1980)

	SFM/SBM			
	0/100	33/67	67/33	100/0[1]
BARLEY-BASED DIETS (15 % P.G.)				
Daily gain (kg)	0.68	0.75	0.67	0.68
Daily intake (kg)	2.27	2.29	2.19	2.23
Feed efficiency	3.12	3.08	3.24	3.29
CORN-BASED DIETS (15 % P.G.)				
Daily gain (kg)	0.77	0.80	0.78	0.83
Daily intake (kg)	2.13	2.22	2.22	2.36
Feed efficiency	2.77	2.79	2.86	2.84

[1]Lysine added to SFM diets to equal level in soybean meal (0/100) diet.

Table 7. 28 vs 44% sunflower meal (SFM) compared to soybean meal (SBM) in growing-finishing swine diets. (Dinusson et al., 1981)

	(SBM) 44 %	(SFM) 44 %[1]	(SFM) 28 %[1]
Daily gain (kg)	0.81	0.75	0.72
Daily intake (kg)	2.72	2.57	2.75
Feed efficiency	3.37	3.51	3.81

[1]Lysine added to SFM diets to equal that in soybean meal diets.

Table 8. Performances of starter pigs (6-19 kg) fed sunflower seed. (Fitzner and Hines, 1988)

	(%),Level of sunflower seed				
	0	10	15	20	25
Daily gain (kg/g)	0.39	0.38	0.38	0.35	0.35
Daily intake (kg/g)	0.69	0.68	0.67	0.59	0.59
Feed efficiency	1.77	1.79	1.76	1.68	1.68

Table 9. Fatty acid composition of sunflower oil. (Dorrell, 1978)

FATTY ACIDS	%
C 16:0 Palmitic	7
C 18:0 Stearic	4
C 18:1 Oleic	17
C 18:2 Linoleic	72

Table 10. Effect of increasing doses of sunflower seed in sow diets on sow performances. (Kepler et al., 1982)

	Sunflower seed (%)		
	0	25	50
Number of farrowings	35	31	30
Pig born alive/litter	9.8	10.1	9.3
Survival to 14 days (%)	74.3	74.8	69.9
Birth weight (kg)	1.5	1.4	1.5
14-Day weight (kg)	3.6	3.6	3.8
Fat in colostrum (%)	5.4	6.4	6.6
Fat in milk (%)	7.8	10.1	11.4

Table 11. Comparison of rumen protein degradability between sunflower meal and soybean meal.(I.V.V.O.)

	C.P. % D.M.	W (%)	U (%)	Kd	B (%)
SOYBEAN MEAL	49.5	6.2	0.1	8.25	40 (100)
SUNFLOWER MEAL	37.2	14.7	3.3	14.68	27 (67.5)

W= Water soluble fraction; U= undegradable fraction; Kd= Rate of degradation (%/h)
B= by-pass calculated using a rate of passage of 6%/h

Table 12. Comparison of rumen protein degradability between sunflower meal and soybean meal.(Piva et al., 1992)

	C.P. % D.M.	a (%)	Kd	B (%)
SOYBEAN MEAL	49.94	23.31	3.96	34.12 (100)
SUNFLOWER MEAL	36.72	37.76	5.33	22.49 (65.9)

a= soluble fraction; Kd= Rate of degradation (%/h)
B= by-pass calculated using a rate of passage of 6%/h

Table 13. Comparison between sunflower meal and soybean meal in dairy cows diets [1].

MILK PRODUCTION	20 kg	
	SUNFLOWER	SOYBEAN
Differences from the requirements	20 kg	20 kg
Degradable protein	+ 206 g	+ 90 g
By-pass protein	- 190 g	- 63 g
Lysine	- 11 g	0
Methionine	- 3 g	- 2 g
Histidine	- 13 g	- 10 g

[1]Composition of the diet, in kg as feed: Corn silage 20, Alfalfa hay-silage 15, Sunflower 1.8 (Soybean 1.4), Barley 1.5, Corn 1.5, Beet pulp 2, Alfalfa hay 1.

Table 14. Comparison between sunflower meal and soybean meal in dairy cows diets[1].

MILK PRODUCTION	30 kg	
	SUNFLOWER	SOYBEAN
Differences from the requirements		
Degradable protein	+ 268 g	+ 45 g
By-pass protein	- 222 g	+ 19 g
Lysine	- 16 g	0
Methionine	- 6 g	- 2.5 g
Histidine	- 15 g	- 9 g

[1]Composition of the diet in kg as feed: Corn silage 20, Alfalfa hay-silage 15, Sunflower 3.5 (Soybean 2.7), Barley 3, Corn 3, Beet pulp 2, Alfalfa hay 1.

Table 15. Comparison between different protein digestibility indexes of soybean and sunflower meal having different protein content. (I.N.R.A.)

	SOYBEAN MEAL	SUNFLOWER MEAL DEHULLED	SUNFLOWER MEAL PART. DEHULLED	SUNFLOWER MEAL WHOLE SEED
C.P. % D.M.	48.8	49.7	38.0	33.7
Dig. C.P. % D.M.	43.8	44.1	32.6	28.5
PDIA (% D.M.)	18.5	10.8	8.2	7.3
PDIN (% D.M.)	34.8	32.1	24.5	21.8
PDIE (% D.M.)	24.1	15.9	12.8	11.1

Table 16. Ratios available feed protein/feed protein content and between two different sources of available rumen bacterial protein, in sunflower meal and soybean meal, as a function of ADF content. (I.N.R.A.)

	SOYBEAN MEAL	SUNFLOWER MEAL DEHULLED	SUNFLOWER PART. DEHULLED	SUNFLOWER MEAL NOT DEHULLED
ADF % D.M.	10.4	19.1	26.6	29.2
% PDIA/% C.P.	0.379	0.217	0.216	0.217
PDIN/PDIE	1.44	2.01	1.91	1.96

Table 17. Transfer efficiencies[1] of serum amino acids in cows fed diets containing soybean meal (SBM) or soy-sunflower blend (SSF). (Drackley e Schingoethe, 1986)

AMINOACIDS	SBM	SSF	
Methionine	59.4	61.4	(1)
Lysine	49.9	44.4	(2)
Phenilalanine	46.9	40.2 *	(3)
Threonine	33.6	33.9	(4)
Valine	15.6	12.4 *	(8)
Isoleucine	25.5	18.0 **	(7)
Leucine	35.6	27.9 **	(5)
Histidine	22.8	21.0	(6)
Arginine	9.0	8.3	(10)
Tryptophan	12.9	11.6	(9)

[1](Amino acid output in milk (g/d)/arterial serum aminoacid (g/l) x serum flow (l/d)) x 100
* (P<0,1)
* * (P<0,05)

Table 18. DT, dr and indigestible N values of some feedstuffs for ruminants. (Piva et al., 1990)

FEEDS	DT %	dr %	DIGESTIBLE N (% of ingested N)
Soybean meal	63.34	95.77	99.05
Sunflower	74.08	89.75	96.89
Corn gluten feed	35.05	98.01	98.71
Fish meal 70 %	48.27	91.39	95.60
Meat meal	49.00	67.47	74.80
Blood meal (type roller)	20.00	41.73	62.18

Table 19. Intestinal absorbable aminoacids (g/100 g of C.P.) of some feeds for Ruminants. (Piva et al., 1990)

FEEDS	LYSINE	METHIONINE
Soyabean meal	18.20	6.50
Sunflower meal	14.20	5.86
Corn gluten meal	4.65	12.03
Fish meal 70 %	40.66	14.59
Meat meal	17.06	4.83
Blood meal	41.04	5.98

Table 20. Milk yield, composition, dry matter intakes and body weights for cows fed diets containing soybean meal (SBM) or soy-sunflower blend (SSF). (Drackley e Schingoethe, 1986)

	SBM	SSF
Milk production (kg/d)	33.6	33.8
Milk production 4% FCM (kg/d)	30.9	30.5
Fat %	3.55	3.10**
Protein %	2.91	2.74**
Dry matter intake (kg/d)	21.7	21.7
Body weight (kg)		
beginning	605	599
ending	612	595

** (P<0,05)

Table 21. Fatty acid composition (wt %) of milk from cows fed sunflower seeds (10% on a D.M. basis). (Mc Gufffey and Schingoethe, 1982)

FATTY ACID[a]	RATION Corn+SBM	 Sunflower rolled	 Sunflower extruded
C 4:0	2.29	2.29	0.99
C 6:0	2.56	2.78	1.89
C 8:0	1.89	2.06	1.46
C 10:0	5.88	4.64	4.30
C 12:0	5.01	4.00	4.30
C 14:0	17.01b	12.40c	12.42c
C 16:0	31.19b	22.29c	22.24c
C 18:0	11.25c	16.38b	16.50b
C 18:1	19.83c	29.13b	29.97b
C 18:2	1.55c	2.47c	4.19b

[a] expressed as number of carbons: number of double bonds ; SBM=soybean meal
[b,c] means on same line with different superscripts differ (P<0,05)